

REMARKS

Claims 15-18 and 23-25 are pending. Claims 15-18 and 23-25 have been rejected under 35 U.S.C. §112, first paragraph, under 35 U.S.C. §112, second paragraph, and under 35 U.S.C. §103. Claims 15 and 16 have been objected to. Claims 15 and 25 have been amended. Support for these amendments is found in claim 23 and in paragraphs [0017] and [0040] of the specification. Claims 1-14, 19-22, and 26-29 have been canceled in previous correspondence. Claims 16 and 23 are canceled herein. Claims 15, 17, 18, 24, and 25 remain for consideration upon entry of the present Amendment. No new matter has been added.

Claims 15-18 and 23-25 have been rejected under 35 U.S.C. §112, first paragraph, because the specification, while being enabling for specific combinations of internal fill gas pressure and carbon monoxide volume percent, allegedly does not reasonably provide enablement for combinations of internal pressure of fill gas of at least 3 bar and volume percent of carbon monoxide of at least 4% that are outside the specific combinations. Claims 15-18 and 23-25 have also been rejected under 35 U.S.C. §112, first paragraph, as allegedly failing to comply with the enablement requirement and allegedly containing subject matter that was not described in the specification in such a way as to enable one skilled in the art to make and/or use the invention.

Claims 15 and 25 have been amended as indicated above to reflect the internal pressure of the fill gas being at least 2 bar (abs) at room temperature (as previously claimed). The proportion of carbon monoxide being at least 4 volume percent is originally defined in the dependent claims. Thus, the combination of the values for the internal pressure for the fill gas to be 2 bar and the proportion of carbon monoxide to be at least 4 volume percent is clearly supported in the application as filed. There is a clear teaching to the person skilled in the art to use these values when constructing a fuel rod for a boiling water reactor.

Also, it should be noted from the specification that on page 14, paragraph [0043], the values recited in the Table in the application are merely exemplary and other values can be calculated. For example, this paragraph indicates that the volume percent of carbon monoxide can be decreased if the inner surface is pre-oxidized. In addition, it is specifically pointed out in this paragraph that “a lower reduction of hydrogen absorption and therefore a lower amount of carbon monoxide in the fill gas than that which has been stated in the following table for specific internal pressures P_{fill} may be chosen.”

The addition of a certain amount of carbon monoxide is significant. The value of the initial internal pressure of the fill gas has been introduced, at least to clarify that the fuel rod is one for a boiling water reactor (in contrast to a fuel rod for a pressure water reactor where the initial internal pressure was defined in the originally filed application to be 10 bar.

Therefore, in view of the amendments to claims 15 and 25 and for the foregoing reasons, Applicants assert that claims 15, 17, 18, 24, and 25 are in compliance with 35 U.S.C. §112, first paragraph, and respectfully request that the Examiner withdraw the rejection.

Claims 15-18 and 23-25 have further been rejected under 35 U.S.C. §112, first paragraph, as being based on a disclosure that is allegedly not enabling. In particular, the Examiner alleges that the condition that the ratio of the partial pressure of the carbon monoxide to the partial pressure of the fill gas is above a critical value, which is allegedly essential to the practice of the invention but not included in the claims, is not enabled by the disclosure.

The Examiner's statement that the ratio of the partial pressure of carbon monoxide to the partial pressure of the fill gas being above a critical value is an essential feature is erroneous. On page 13, paragraph [0041], and on page 14, paragraph [0042], a certain critical value F_{krit} is defined. This value refers to the ratio of the partial pressure of carbon monoxide to the partial pressure of hydrogen. However, hydrogen will enter the inner space of the fuel rod only after a defect has arisen. The critical value of this ratio is thus a value which can be expected after a defect has arisen. This ratio is not a relevant feature of a fuel rod immediately after having been produced and to be sold (i.e., a fuel rod that is not defective). Therefore, the condition that the ratio of the partial pressure of the carbon monoxide to the partial pressure of the fill gas is above a critical value is not essential to the practice of the invention.

For the foregoing reasons, Applicants accordingly assert that claims 15, 17, 18, 24, and 25 are in compliance with 35 U.S.C. §112, first paragraph, and respectfully request that the Examiner withdraw the rejection.

Claims 15-18 and 23-25 have been rejected under 35 U.S.C. §112, second paragraph, as allegedly being indefinite for failing to particularly point out and distinctly claim the subject matter that Applicants regard as the invention. In particular, the Examiner alleges that claims 15 and 25 each recite the internal pressure of the fill gas of at least 3 bar (abs) at "room temperature," and that the claims are vague, indefinite, and incomplete and their metes

and bounds cannot be determined because there is not one, unique room temperature at all places at all times. The Examiner also alleges that the claims are vague, indefinite, and incomplete because they are inconsistent with regard to the allowable combinations of fill gas pressure and carbon monoxide volume percent.

Applicants respectfully assert that the term “room temperature” is not indefinite. Any person skilled in the pertinent art will understand the expression “room temperature” as being the typical, ambient temperature that prevails in the facilities where the fuel rod is manufactured and that the internal pressure of the fill gas is determined at this temperature. Furthermore, the term “room temperature” is clearly distinguishable from the term “operational temperature” as described in the specification on page 14, paragraph [0042].

In view of the foregoing, Applicants respectfully assert that claims 15 and 25 (and claims 17, 18, and 24, which depend from claim 15) are definite within the meaning of 35 U.S.C. §112, second paragraph. Accordingly, Applicants respectfully request that the Examiner withdraw the rejections of the claims under 35 U.S.C. §112, second paragraph.

Claims 15-18 and 23-25 have been rejected under 35 U.S.C. §112, second paragraph, as allegedly being incomplete for omitting essential elements, such omission amounting to a gap between elements. In particular, the omitted element is alleged to be the condition that the ratio of the partial pressure of the carbon monoxide to the partial pressure of the fill gas is above a critical value.

As stated above, the Examiner’s statement that the ratio of the partial pressure of carbon monoxide to the partial pressure of the fill gas being above a critical value is an essential feature is erroneous. As stated above, the critical value F_{krit} refers to the ratio of the partial pressure of carbon monoxide to the partial pressure of hydrogen, but hydrogen will enter the inner space of the fuel rod only after a defect has arisen. The critical value of this ratio is thus a value which can be expected after a defect has arisen, and this ratio is not a relevant feature of a fuel rod immediately after having been produced.

For the foregoing reasons, Applicants respectfully assert that claims 15 and 25 (and claims 17, 18, and 24, which depend from claim 15) are definite within the meaning of 35 U.S.C. §112, second paragraph. Accordingly, Applicants respectfully request that the Examiner withdraw the rejections of the claims under 35 U.S.C. §112, second paragraph.

Claims 15 and 16 have been objected to as allegedly being substantial duplicates of each other.

Claim 16 has been cancelled, as indicated above, thereby rendering the Examiner's objection to the claim moot.

Claims 15-18 and 23-25 have been rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 4,609,524 to Ferrari (hereinafter "Ferrari '524") in view of U.S. Patent No. 3,677,894 to Ferrari (hereinafter "Ferrari '894") in combination with either U.S. Patent No. 5,437,747 to Adamson et al. (hereinafter "Adamson") or U.S. Patent No. 5,329,566 to King (hereinafter "King"). The Examiner alleges that it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the fuel rod in Ferrari '524 by the teaching of Ferrari '894 to have an initial fill gas pressure of at least 3 bar to gain the advantages thereof (i.e., to prevent deformation of the fuel rod) because such a modification is no more than the use of a well known expedient within the nuclear art.

Claims 15 and 25 have been amended as indicated above. The present invention improves the resistance of a nuclear fuel rod against secondary hydriding and secondary degradation. Hydriding means that hydrogen is adsorbed and subsequently absorbed by the cladding material, which leads to an embrittlement of the material. Hydrogen will reach the interior of the cladding in the case that a small primary defect occurs. A primary defect may, as a consequence of the hydriding, lead to a secondary defect and secondary degradation.

The purpose of the present invention is achieved by the fuel rod and the fuel assembly as defined in claims 15 and 25, respectively. A certain amount of carbon monoxide is added to the fill gas during manufacturing of the surface of the fuel rod. This carbon monoxide will remain in the fill gas and be adsorbed at positions on the surface of the zirconium material of the cladding tube, namely, in positions where hydrogen in the case of a primary defect would have been adsorbed and subsequently absorbed.

Consequently, the carbon monoxide will prevent adsorption of hydrogen and in such a way prevent hydriding and degradation of the zirconium material of the cladding tube. The amount of carbon monoxide required depends on the internal pressure in the fuel rod. In claims 15 and 25, the amount of carbon monoxide is adapted to the initial internal pressure normally prevailing in a fuel rod for a boiling water nuclear reactor at room temperature.

Ferrari '524, on the other hand, is directed to a fuel rod 1 comprising a metallic cladding tube 2 that forms an inner space 5 containing fuel pellets 6 and a fill gas of mainly helium. Ferrari '524 proposes to add to the fill gas a minor amount of a gas selected from the group consisting of oxygen, carbon monoxide, and carbon dioxide. Ferrari '524 does not

specifically point out carbon monoxide, but it does emphasize carbon dioxide as recited in a dependent claim (claim 2).

For the purpose of the present invention, carbon monoxide is selected as the gas that is additional to the fill gas, whereas Ferrari '524 utilizes oxygen or carbon dioxide as well as carbon monoxide.

In Ferrari '524 the added gas has the purpose of forming an oxide layer on the inner surface of the cladding tube during operation of the fuel rod. The purpose of the oxide layer of Ferrari '524 is to reduce the permeation of tritium through the cladding tube. It can be seen that the cladding tube in Ferrari '524 is a metallic tube with no oxide layer on the surfaces and that the added gas will be effective to form an oxide layer on the inner surface of the metallic tube (as in claim 1 of Ferrari '524). The amount of gas added to the fill gas will thus not remain according to the teaching of Ferrari '524, but the added gas will be consumed when forming the oxide layer on the inner surface of the cladding tube. Consequently, the amount of the added gas will decrease after an initial use of the fuel rod.

In view of the amendment to claims 15 and 25 in which a protective oxide layer is included on the inner surface of the cladding, it is clear that the carbon monoxide of the fill gas does not have the purpose of forming a protective oxide layer, but instead the purpose of being absorbed by the zirconium material to prevent absorption of hydrogen in the case of a primary defect.

Also, it should be noted that the Applicants, when developing the present invention, have performed experiments with different amounts of carbon monoxide. According to such experiments, carbon monoxide does not seem to be a substance which would form an oxide layer on a metallic surface. The experiments performed by the Applicants have also shown that the carbon monoxide to a large extent will remain in the fill gas during operation of the nuclear reactor. In Ferrari '524, however, the added gas is not intended to remain in the fill gas but to be consumed to form the oxide layer on the inner surface of the cladding tube. These experiments thus confirm that carbon dioxide would be the preferred gas according to the teachings of Ferrari '524, at least in comparison with carbon monoxide, which is (as mentioned above) already indicated in claim 2 of Ferrari '524.

Ferrari '894 discloses a fuel rod having a body 24 provided above the stack of fuel pellets 12 and beneath the plenum spring 30. Ferrari '894 defines internal pressures in the fuel rod (Ferrari '894, column 3, lines 15-33). These pressures seem to apply to a fuel rod for

a pressure water reactor as indicated in column 1, lines 33-35. The body 24 is made of a material which is thermally decomposable to generate a gas to create an internal pressure within the fuel rod. The body may be made of an iron oxalate which is decomposed at a temperature of 160 degrees C to iron and carbon dioxide and to iron oxide, carbon monoxide, and carbon dioxide. However, and as acknowledged by the Examiner, Ferrari '894 does not suggest the carbon monoxide proportion defined in claims 15 and 25 of the present application.

Adamson discloses a method for the fabrication of Zircaloy tubing, i.e., a method of producing the cladding tube. As indicated by the Examiner Adamson disclosed that "other phenomena such as local hydriding of the cladding in the presence of the oxygen, nitrogen, carbon monoxide, and carbon dioxide can assist cladding failure and lead to rod cracking." (Adamson, column 3, lines 49-52.) Consequently, Adamson clearly teaches the person skilled in the art away from the present invention and the addition of carbon monoxide to the fill gas.

King discloses a fuel rod and is particularly concerned with the plenum and the plenum spring in the upper part of the fuel rod. As indicated by the Examiner, King also discloses that the "cladding is also adversely affected by such gases as oxygen, nitrogen, carbon monoxide, and carbon dioxide at all temperatures." (King, column 1, lines 47-50.) Consequently, King clearly teaches away from the present invention and the addition of carbon monoxide to the fill gas.

None of the cited references (Ferrari '524, Ferrari '894, Adamson, and King), individually or in combination, propose the addition of the claimed proportion of carbon monoxide to the fill gas, and particularly not in combination with a pre-oxidation of the inner surface of the cladding tube. King and Adamson would, if considered, lead one of ordinary skill in the art to reducing the carbon monoxide content proposed in Ferrari '524 rather than increasing the content of the carbon monoxide in the fill gas to the claimed proportion.

Accordingly, because none of Ferrari '524, Ferrari '894, Adamson, and King, individually or in combination, disclose, teach, or suggest what Applicants claim in claims 15 and 25 as amended, namely, the addition of the claimed proportion of carbon monoxide to the fill gas and a pre-oxidation of the inner surface of the cladding tube, Ferrari '524, Ferrari '894, Adamson, and King, individually or in combination, each fail to teach all of the claim recitations of Applicants' invention. Consequently, because not all of the claim recitations

are taught by the cited references, Applicants' amended claims 15 and 25 are necessarily non-obvious, and Applicants respectfully request that the Examiner withdraw the rejections thereof.

Claims that depend from a claim that is non-obvious are themselves necessarily non-obvious. Because claims 17, 18, and 24 depend from claim 15, and because claim 15 is asserted to be non-obvious for the reasons presented above, claims 17, 18, and 24 are likewise necessarily non-obvious. Applicants, therefore, respectfully submit that claims 17, 18, and 24 are allowable. Accordingly, Applicants respectfully request that the rejections of claims 17, 18, and 24 be withdrawn.

Applicants believe that the foregoing amendments and remarks are fully responsive to the Office Action and that the claims herein are allowable. An early action to that effect is earnestly solicited.

If the Examiner believes that a telephone conference with Applicants' attorneys would be advantageous to the disposition of this case, the Examiner is invited to telephone the undersigned.

Applicants believe that no fees are due with the submission of this Amendment. If any charges are incurred with respect to this Amendment, they may be charged to Deposit Account No. 503342 maintained by Applicants' attorneys.

Respectfully submitted,

By /Richard R. Michaud/
Richard R. Michaud
Registration No. 40,088
Attorney for Applicants

Michaud-Duffy Group LLP
CenterPoint
306 Industrial Park Road
Suite 206
Middletown, CT 06457-1532
Tel: (860) 632-7200
Fax: (860) 632-8269